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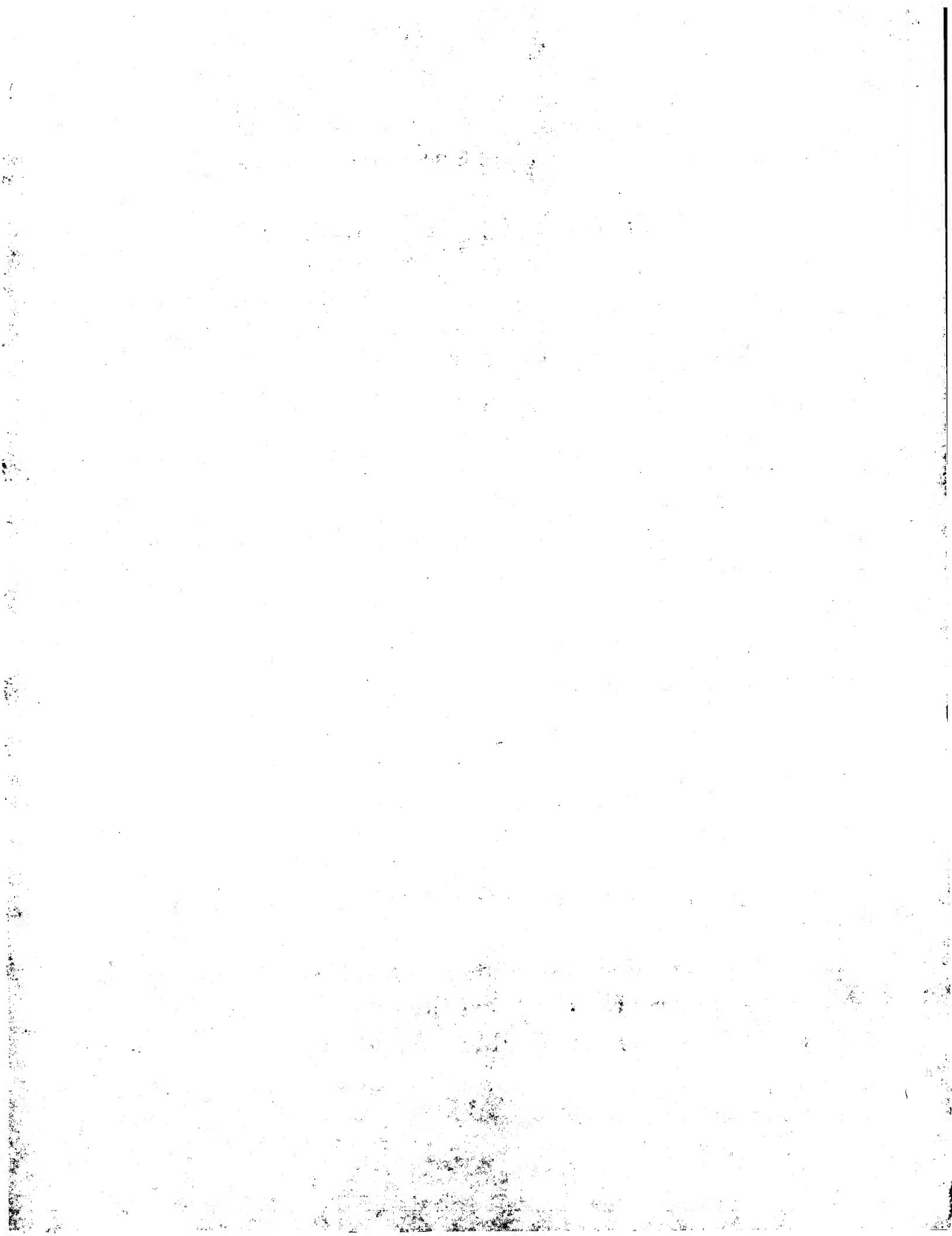
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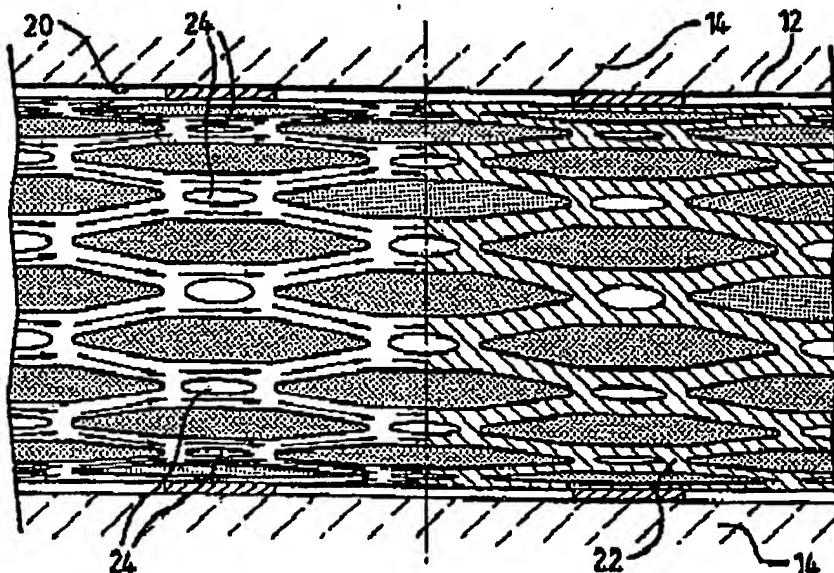
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                         |                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (51) International Patent Classification 6:<br><b>E21B 43/10, 33/10</b>                                                                                                                 | A1                                | (11) International Publication Number: <b>WO 99/02818</b><br>(43) International Publication Date: <b>21 January 1999 (21.01.99)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| (21) International Application Number: <b>PCT/GB98/02066</b>                                                                                                                            |                                   | (81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR,<br>BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE,<br>GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ,<br>L, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW,<br>MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL,<br>T, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO<br>patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian<br>patent (AM, AZ, BY, KG, KZ, MD, RU, TT, TM), European<br>patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR,<br>IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF,<br>CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). |
| (22) International Filing Date: <b>13 July 1998 (13.07.98)</b>                                                                                                                          |                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| (30) Priority Data:<br><b>9714651.8 12 July 1997 (12.07.97) GB</b>                                                                                                                      |                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| (71) Applicant (for all designated States except US): PETROLINE<br>WELL SYSTEMS LIMITED (GB/GB); Offshore Technology Park,<br>Claymore Drive, Bridge of Don, Aberdeen AB23<br>8GD (GB). |                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| (72) Inventor; and                                                                                                                                                                      | Published                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| (73) Inventor/Applicant (for US only): METCALFE, Paul, David<br>(GB/GB); North Wing, Buckleburn Steading, Peterculter<br>AB14 0NP (GB).                                                 | With international search report. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
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(54) Title: DOWNHOLE TUBING



(57) Abstract

There is provided a downhole tubing sealing system (10) comprising a radially expandable slotted tubular body (16) carrying deformable material (22) on the exterior thereof, and a seal member (26) for location within the tubular body and for engaging an inner surface of said body. There is further provided a method of sealing a portion of a downhole bore, the method comprising locating a radially expandable slotted tubular body (16) carrying deformable material (22) on the exterior thereof in a bore, expanding the body radially into contact with the bore wall, and locating a seal member (26) within the body and radially extending the seal member to engage an inner surface of the body, so sealing a portion of the downhole bore.

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DOWNGEOL TUBING

This invention relates to downhole tubing, a downhole tubing sealing system, and to elements of such a system. The invention also relates to a method of lining a bore and to a method for sealing downhole tubing.

5 In oil and gas extraction operations, a bore is drilled through the earth to intersect a hydrocarbon-bearing formation which forms the hydrocarbon reservoir, allowing oil and gas from the reservoir to be transported to the surface. The bore intersecting the reservoir is  
10 typically lined with steel casing which is cemented in the bore. A perforating gun is then lowered into the bore and detonated to form perforations which extend through the casing and the cement and into the formation. Typically,  
15 sets of perforations are provided at intervals along the casing, and the perforated casing may extend for several thousand metres through the formation. To control the flow of oil from the formation inflatable packers may be provided to isolate selected sets of perforations and thus  
isolate the corresponding portions of the formation.

20 It has recently been proposed that such cemented and perforated casing be replaced by expandable slotted tubing, such as described in WO93\25800 (Shell Internationale Research Maatschappij B.V.). Such tubing comprises lengths of tube which have been machined to create a large number  
25 of overlapping longitudinal slots. The tube is radially expanded, while downhole, into contact with the bore wall,

the slots extending to create diamond-shaped apertures. The expanded tube thus provides support for the bore wall while allowing oil to flow into the bore through the extended slots.

5 It is among the objectives of embodiments of the present invention to provide a system which allows a section of bore wall lined with such expanded tubing to be sealed or isolated, and thus facilitate control of the flow of oil from a hydrocarbon reservoir.

10 According to one aspect of the present invention there is provided downhole tubing comprising a radially expandable slotted tubular body carrying deformable material on the exterior thereof.

15 According to a further aspect of the present invention there is provided a downhole tubing sealing system comprising a radially expandable slotted tubular body carrying deformable material on the exterior thereof, and a seal member for location within the body and for engaging an inner surface of the body.

20 In use, the tubular body is located in a bore and expanded radially into contact with the bore wall. The presence of the deformable material on the exterior of the body ensures that full contact is achieved between the outer surface of the body and the bore wall. The sealing member is then activated to engage the inner surface of the body and provides a sealing contact therewith. The length 25 of the seal member and/or the location of the seal member in the body is selected such that none of the slots in the

body extend beyond both ends of the seal member; otherwise, fluid would be able to flow around the seal member by passing along the slots.

According to another aspect of the present invention  
5 there is provided a method of isolating a portion of a downhole bore, the method comprising the steps of:

providing a radially expandable slotted tubular body carrying deformable material on the exterior thereof;

locating the body in a bore and expanding the body  
10 radially into contact with the bore wall; and

locating a seal member within the body and radially extending the member to engage an inner surface of the body.

As used herein the terms "slots" is intended to  
15 encompass any holes or apertures which facilitate expansion of the body, including bores, slots or weakened areas which initially only extend part way through the body.

These aspects of the invention permit the complete sealing of a bore lined with expanded slotted tubing.  
20 Conventional expanded slotted metal tubing does not achieve a fluid-tight metal-to-rock contact: because the outer surface of the tubing tends to retain its original curvature, that is the curvature of the unexpanded tubing, not all of the outer surface contacts the bore wall following expansion. With the inner surface sealed, for example by a packer, there remains a small area S-shaped leak path between the tubing and the bore wall where the tubing is not in contact with the wall; this leak path may

account for around 0.5% of the cross sectional area of a bore. However, with the present invention the deformable material on the outer surface of the body allows complete contact between the body and the bore wall and eliminates  
5 this leak path.

Preferably, the deformable material is an elastomer. Of course the deformable material will be selected to withstand handling and the conditions experienced downhole, for example the selected material preferably bonds to the  
10 body outer surface sufficiently to prevent erosion or degradation during installation, withstands the elevated temperatures experienced downhole (typically 130 - 180°C), and is resistant to crude oils, brines, acids and other fluids likely to be encountered downhole.

15 According to a further aspect of the present invention there is provided a method of lining a downhole bore, the method comprising the steps of:

providing a radially expandable slotted tubular body carrying deformable material on the exterior thereof; and  
20 locating the body in a bore and expanding the body radially into contact with the bore wall.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

25 Figure 1 is a schematic sectional view of a downhole sealing system in accordance with an embodiment of the present invention, shown in a bore;

Figure 2 is an enlarged sectional view on line 2 - 2

of Figure 1; and

Figure 3 is an enlarged side view of the tubing of system of Figure 1, one half of the Figure illustrating the effect of the absence of a deformable material coating as provided in embodiments of the present invention.

The drawings illustrate a downhole tubing sealing system 10 in accordance with an embodiment of the present invention. The system 10 is shown, in Figure 1 of the drawings, in a drilled horizontal bore 12 which intersects an oil bearing formation or reservoir 14.

The system 10 includes tubing 16, similar to that as described in WO93\25800 (Shell Internationale Research Maatschappij B.V.), which includes a large number of overlapping longitudinal slots 18. The tubing 16 is run into the bore 12 in unexpanded configuration and a mandrel then pushed up or pulled through the tubing 16 to expand the tubing radially outwards. The expansion is accommodated by the extension of the slots 18 to form the diamond shaped apertures as illustrated in Figure 3 of the drawings. As may be seen in Figure 2 of the drawings, the tubing 16 is expanded into contact with the bore wall 22, and thus provides support for the bore wall 20 while allowing oil to flow from the reservoir through the expanded slots 18.

The tubing 16 is formed of an appropriate metal, typically steel, and carries an external coating of a deformable material in the form of an elastomer 22. The provision of the elastomer coating allows the outer surface

of the tubing 16 to form a sealing contact with the bore wall 20, as described below.

On expansion of the tubing 16, the metal outer surface of the tubing tends to retain its original curvature, that is the curvature of the unexpanded tubing, as may be seen from Figure 2. As a result, in the absence of an elastomer coating 22, not all of the outer surface of the tubing would contact the bore wall 22 following expansion; metal-to-rock contact would only be achieved at the contact points 24 as indicated in Figures 2 and 3. Thus, it may be seen that, in the absence of the elastomer coating, a small area S-shaped leak path would remain between the tubing and the bore wall where the tubing was not in contact with the wall. However, in the present invention, differential compression of the elastomer coating 22 ensures that there is an elastomer-to-rock contact around the circumference of the tubing (though of course not at the slots 18).

In the illustrated example the reservoir 14 has been isolated from the bore 12 by providing a packer 26 within the tubing 16, the packer providing a sealing contact with the interior of the tubing 16 over the length of the intersection of the bore 12 with the reservoir 14. The packer 26 is mounted on a tube 28 which allows fluid to flow past the isolated reservoir 14.

It will be apparent to those of skill in the art that the above-described embodiment provides numerous advantages over conventional cemented and perforated casing systems, and also other methods of sealing expanded slotted tubing,

such as providing an external isolation sleeve on the tubing. With the present invention, the whole length of the tubing may contribute to flow as all of the slots in the tubing are normally opened. Further, the internal 5 sealing member or packer may be provided at any location in the tubing, and is thus adaptable to deal with any situation or problems that may arise in a bore.

It will also be clear to those of skill in the art that the above-described embodiment is merely exemplary of 10 the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the present invention.

CLAIMS

1. Downhole tubing comprising a radially expandable slotted tubular body carrying deformable material on the exterior thereof.
- 5 2. The downhole tubing of claim 1 wherein said deformable material is an elastomer.
3. The downhole tubing of claim 2 wherein said elastomer is selected to be resistant to high temperatures, and to crude oils, brines, acids, and other degradative fluids encountered downhole.
- 10 4. A downhole tubing sealing system comprising the downhole tubing of claims 1 to 3, and a seal member for location within said body and for engaging an inner surface of said body.
- 15 5. A method of isolating a portion of a downhole bore, the method comprising the steps of:  
providing a radially expandable slotted tubular body carrying deformable material on the exterior thereof;  
locating said body in a bore and expanding said body radially into contact with the bore wall; and  
20 locating a seal member within said body, and radially extending said member to engage an inner surface of said

body.

6. A method of lining a downhole bore, the method comprising the steps of:

providing a radially expandable slotted tubular body carrying deformable material on the exterior thereof; and  
5 locating said body in a bore and expanding said body radially into contact with the bore wall.

DOWNHOLE TUBINGABSTRACT

There is provided a downhole tubing sealing system (10) comprising a radially expandable slotted tubular body (16) carrying deformable material (22) on the exterior thereof; and a seal member (26) for location within the tubular body and for engaging an inner surface of said body. There is further provided a method of sealing a portion of a downhole bore, the method comprising locating a radially expandable slotted tubular body (16) carrying deformable material (22) on the exterior thereof in a bore, expanding the body radially into contact with the bore wall, and locating a seal member (26) within the body and radially extending the seal member to engage an inner surface of the body, so sealing a portion of the downhole bore.

1/2

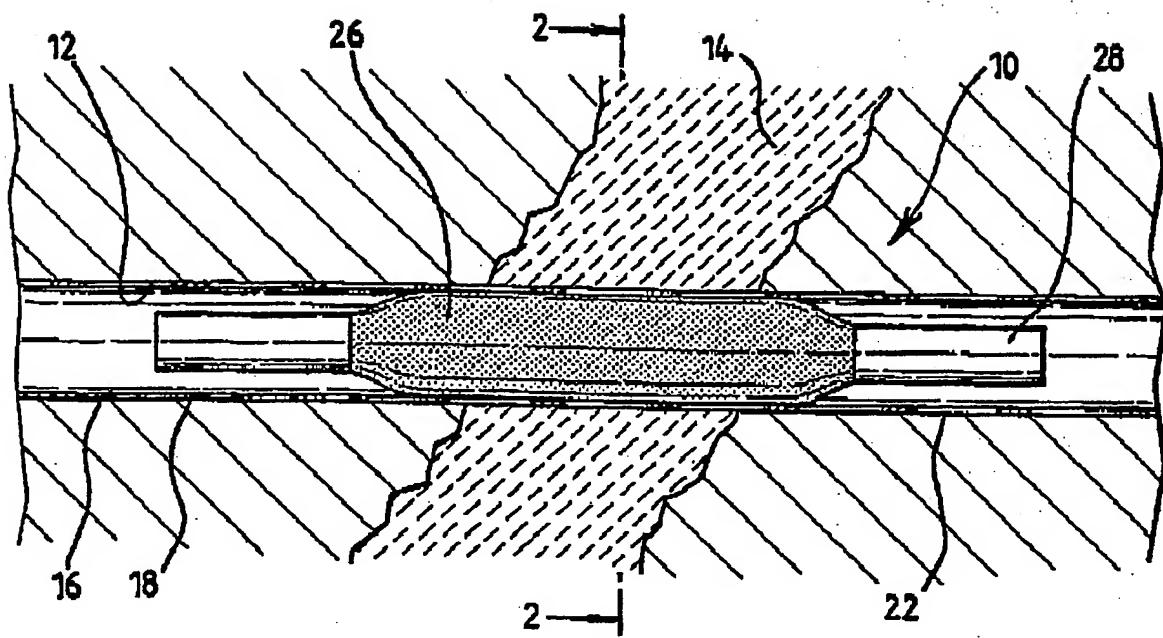


FIG. 1

2/2

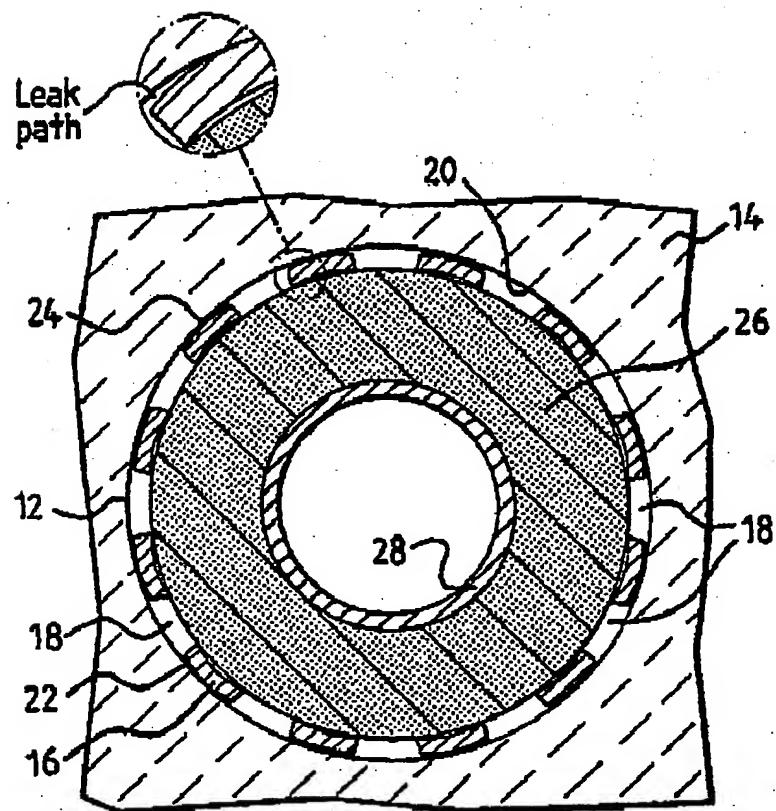


FIG. 2

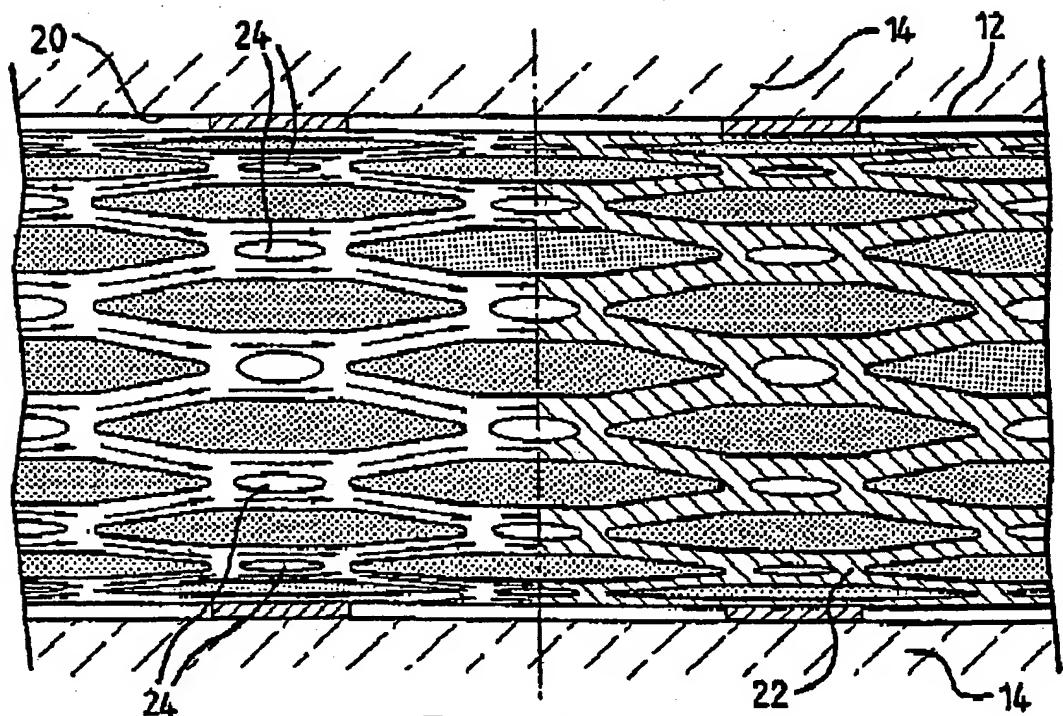


FIG. 3

# INTERNATIONAL SEARCH REPORT

National Application No  
PCT/GB 98/02066

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 E21B43/10 E21B33/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages                                                                           | Relevant to claim No. |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X          | WO 94 25655 A (DRILLFLEX) 10 November 1994<br>see page 5, line 30 - page 6, line 21<br>see page 7, line 25 - page 8, line 5<br>see page 9, line 26 - line 31 | 1-3, 6                |
| A          | US 3 746 091 A (OWEN ET AL.) 17 July 1973<br>see column 7, line 7 - line 16                                                                                  | 1                     |
| A          | US 3 489 220 A (KINLEY) 13 January 1970<br>see column 2, line 36 - line 55<br>see column 6, line 70 - line 75                                                | 1                     |
| A          | US 3 353 599 A (SWIFT) 21 November 1967<br>see column 4, line 71 - column 5, line 30                                                                         | 1                     |
| A          | US 3 669 190 A (SIZER ET AL.) 13 June 1972<br>see abstract                                                                                                   | 4, 5                  |

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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"A" document member of the same patent family

Date of the actual compilation of the international search

Date of mailing of the international search report

19 October 1998

23/10/1998

Name and mailing address of the ISA

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Fax: (+31-70) 340-3016

Authorized officer

Rampelmann, K

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 98/02066

## C(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Description of document, with indication, where appropriate, of the relevant passages                                                                                                          | Relevant to claim No. |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A        | METCALFE P: "EXPANDABLE SLOTTED TUBES OFFER WELL DESIGN BENEFITS"<br>PETROLEUM ENGINEER INTERNATIONAL,<br>Vol. 69, no. 10, October 1996, pages<br>60-63, XP000684479<br>see the whole document | 1,6                   |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No  
PCT/GB 98/02066

| Patent document<br>cited in search report | Publication<br>date |            | Patent family<br>member(s)                                                                                                                                  | Publication<br>date                                                                                                                      |
|-------------------------------------------|---------------------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| WO 9425655                                | A                   | 10-11-1994 | FR 2704898 A<br>AU 673261 B<br>AU 6660194 A<br>CA 2162035 A<br>CN 1122619 A<br>DE 69412252 D<br>EP 0698136 A<br>JP 8509532 T<br>NO 954299 A<br>US 5695008 A | 10-11-1994<br>31-10-1996<br>21-11-1994<br>10-11-1994<br>15-05-1996<br>10-09-1998<br>28-02-1996<br>08-10-1996<br>07-12-1995<br>09-12-1997 |
| US 3746091                                | A                   | 17-07-1973 | NONE                                                                                                                                                        |                                                                                                                                          |
| US 3489220                                | A                   | 13-01-1970 | NONE                                                                                                                                                        |                                                                                                                                          |
| US 3353599                                | A                   | 21-11-1967 | NONE                                                                                                                                                        |                                                                                                                                          |
| US 3669190                                | A                   | 13-06-1972 | NONE                                                                                                                                                        |                                                                                                                                          |

# PATENT COOPERATION TREATY

From the:  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

McCALLUM, W.  
CRUIKSHANK & FAIRWEATHER  
19 Royal Exchange Square  
Glasgow G1 3AE  
GRANDE BRETAGNE

**PCT**

**WRITTEN OPINION**

**(PCT Rule 66)**

Date of mailing  
(day/month/year)

15 04 1999

**REPLY DUE**

within 3 month(s)  
from the above date of mailing

Applicant's or agent's file reference  
AS/LD/PO8352PC

International application No.

PCT/GB98/02066

International filing date (day/month/year)

13/07/1998

Priority date (day/month/year)

12/07/1997

International Patent Classification (IPC) or both national classification and IPC

E21B43/10

Applicant

PETROLINE WELLSYSTEMS LIMITED et al.

1. This written opinion is the first drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I     Basis of the opinion
- II     Priority
- III     Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV     Lack of unity of invention
- V     Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI     Certain document cited
- VII     Certain defects in the international application
- VIII     Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendment, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis. For an informal communication with the examiner, see Rule 66.8.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 12/11/1999.

Name and mailing address of the international preliminary examining authority:

European Patent Office - P.B. 5818 Patentkantoor 2  
NL-2280 HV Rijswijk - Pays Bas  
Tel. (+31-70) 340-2040 Tx. 31 651 epo nl  
Fax: (+31-70) 340-3016

Authorized officer / Examiner

Rampelmann, K

Formalities officer (incl. extension of time limits)

Kruydenberg, G



**WRITTEN OPINION**

International application No. PCT/GB98/02066

**I. Basis of the opinion**

1. This opinion has been drawn on the basis of (substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed").

**Description, pages:**

1-7                   as originally filed

**Claims, No.:**

1-6                   as originally filed

**Drawings, sheets:**

1/2-2/2              as originally filed

**2. The amendments have resulted in the cancellation of:**

- the description,    pages:
- the claims,       Nos.:
- the drawings,      sheets:

**3. This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):****4. Additional observations, if necessary:****V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty (N)           Claims 1, 2, 6

Inventive step (IS)   Claims 3, 4

Industrial applicability (IA)   Claims

**2. Citations and explanations**

see separate sheet

**WRITTEN OPINION**

International application No. PCT/GB98/02066

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**VII. Certain defects in the International application**

The following defects in the form or contents of the international application have been noted:

**see separate sheet**

**VIII. Certain observations on the International application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

**see separate sheet**

For the purpose of this written opinion, claim 4 is considered as dependent claim, since it contains all the technical features of claims 1 to 3 (cf. Rule 6.4 PCT); the claim should be redrafted accordingly.

**Re Item V**

**Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. With respect to claim 1, document WO-A-94/25655 discloses (see page 5, lin 30 - page 6, line 21; page 7, line 25 - page 8, line 5; page 9, lines 26-31; figs. 1, 4) a downhole tubing (1, 3a) comprising a radially expandable slotted tubular body carrying deformable material (4) on the outside thereof.

WO-A-94/25655 shows tube 1 (fig. 4) made of three deformable tubular structures 3a, 3b, 3c. Each single tube is made of braided strands 10 which leave gaps 11 at the intersection (fig. 2A).

On page 3 of the description of the present application it says that slots are understood as any hole or aperture which facilitate expansion, so that the gaps 11 of WO-A-94/25655 are considered as slots.

Therefore, the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

2. The additional features of claim 2 are also known from WO-A-94/25655 so that its subject-matter is also not new.

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3. The selection of a particular elastomer does not involve an inventive step, since the skilled person would do so in accordance with circumstances, i.e. downhole conditions, without the exercise of inventive skill.

4. The additional features of claim 4 are known from US-A-3.669.190 (see col. 8, lines 8-23) so that the subject-matter of claim 4 does not appear to involve an inventive step.

5. With respect to claim 1, document WO-A-94/25655 discloses (see page 5, lin 30 - page 6, line 21; page 7, line 25 - page 8, line 5; page 9, lines 26-31; figs. 1, 4) a method of lining a downhole bore, the method comprising the steps of : providing a radially expandable slotted tubular body carrying deformable material (4) on the outside thereof; and locating the body in a bore and expanding the body radially into contact with the bore wall.

Therefore, the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.

6. It is at present not evident to which combination of features the applicant intends to link an inventive step in order to obtain a claim directed to a downhole tubing and to a method of lining a downhole bore.  
The applicant is invited to file new claims incorporating such features. The new claims should be drafted in the two part form, with those features known from WO-A-94/25655 being placed in the preamble (cf. Rule 6.3 (b) PCT).

**Re Item VII**

**Certain defects in the international application**

- a) The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT). ;;
- b) The document WO-A-94/25655 should be mentioned in the description and the relevant background art disclosed therein should be briefly discussed (Rule 5.1(a)(ii) PCT).
- c) When filing amended claims the applicant should at the same time bring the description into conformity with the amended claims. Care should be taken during revision, especially of the introductory portion and any statements of problem or advantage, not to add subject-matter which extends beyond the content of the application as originally filed.

**WRITTEN OPINION  
SEPARATE SHEET**

International application No. PCT/GB98/02066

**Re Item VIII**

**Certain observations on the international application**

The statement in the description on page 7 implies that the subject-matter for which protection is sought may be different to that defined by the claims, thereby resulting in lack of clarity (Article 6 PCT) when used to interpret them (see also the PCT Guidelines, PCT/GL/3 III, 4.3a).

